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FRIDAY, AUGUST 14, 1896.

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*PALEONTOLOGY AS A MORPHOLOGICAL DISCIPLINE.**

THE day has forever gone by when any one mind, however profound and comprehensive, can take all knowledge for its province. Increase of knowledge, like advance of civilization, necessarily brings with it a division of labor, and each of the great branches of science becomes more and more minutely divided and subdivided for the purposes of investigation. Such subdivision greatly enhances the efficiency of the individual worker, enabling him to concentrate his attention upon some definite problem of more or less limited scope, and, so far, it is advantageous. On the other hand, like most human devices, it has its drawbacks, and what is gained in one direction is apt to be lost in another. One great and growing evil is the subdivision of *knowledge* which accompanies specialization of research. The worker finds the greatest difficulty in keeping abreast of all that is being accomplished by fellow laborers in his own field; how, then, shall he find time to learn anything of the work in other fields? Not to do so involves the penalty of such a narrowness of view as will inevitably lessen the value of his own work, because deductions drawn legitimately enough from a single line of investigation often appear absurd when tested by a wider range of facts. Many a blunder might be avoided, were the worker's vision not so strictly limited by the boundaries of his own speciality.

The narrowing effects of this subdivision of knowledge result in a more or less marked loss of sympathy and mutual understanding between the representatives of the different branches of the same science. To

*A lecture given at the Marine Biological Laboratory, Wood's Holl, printed in advance of its publication in the Lectures of the Marine Biological Laboratory by permission of the Director, Prof. Whitman.

magnify one's own office is a very human infirmity, but it involves a minimizing of the offices of others. Science is not advanced by the sneers of its representatives at one another as mere 'species-makers,' or 'section-cutters,' or 'closet-naturalists,' as the case may be. One is prone to regard with instinctive distrust results which run counter to cherished convictions, or which ill harmonize with prevalent theories and call for a radical readjustment of opinion. Naturally the investigator is apt to place undue reliance upon the methods with which he is familiar and to undervalue other ways of attacking the same problem. Evidence derived from other lines of investigation means less to him and is the more readily overlooked and ignored. Perhaps the greatest danger which at present threatens the healthy growth of zoological science in all its branches is the ever-increasing tendency to ambitious speculation, founded upon the narrowest basis of fact. So much of a theoretical taint attaches to nearly all morphological work as to cause hesitation in fully accepting it, and one often feels in reading that we have gone back to the days of the transcendental anatomists. The glib use of phrases and formulæ, which hide ignorance under the guise of 'explanations' which do not explain, is an outgrowth of the same tendency. It is the fashion to measure with elastic standards, which expand and contract to meet the needs of each case. Dogmatism and narrow-mindedness have ever been closely akin.

The obvious corrective for many of these evils is to take a wider view of our subject, and for each of us to learn something of the methods and results of workers in other fields than our own. I wish to invite your attention to a branch of morphology, the bearings of which are much misapprehended by the representatives of other departments of the same science, and which, where not completely ignored, is often wofully abused, namely, the subject of paleontology. This science has too long been abandoned to the geologist, but morphologists are coming to see that they have an interest in it, and sometimes condescend to make use of such parts of its data as favor their opinions. Even yet, however, the necessary and close connection which obtains between paleontology and geology leads many to the assumption that its relation to morphology is, at best, very remote; but this assumption is quite unjustified, and proceeds from a confounding of the two quite distinct aspects and offices of paleontology. One of these offices is to determine the chronological succession of the rocks, and in this morphology is very indirectly concerned; but the other office is the study of fossils as organisms, and here Huxley's dictum thoroughly applies: "The only difference between a collection of fossils and one of recent animals is that one set has been dead somewhat longer than the other." This is a shining example of the 'true word spoken in jest.'

The great problems of morphology are the same for all workers in that science; it is the method of attacking them which differs. If I may be allowed to quote what I have elsewhere said, I would again call attention to the very instructive character of the analogies which exist between the history, aims and methods of animal morphology and those of comparative philology. "In both sciences the attempt is made to trace the development of the modern from the ancient, to demonstrate the common origin of things now widely separated and differing in all apparent characteristics, and to establish the modes in which, and the factors or causes by which, this evolution and differentiation have been affected. At the present time morphology is still far behind the science of language with regard to the solution of many of these kindred problems,

and can hardly be said to have advanced beyond the stage which called forth Voltaire's famous sneer: 'L'étymologie est une science où les voyelles ne font rien et les consonnes fort peu de chose.' Of the animal pedigrees, now so frequently propounded, few have any better foundation than the guessing etymologies of the last century, and for exactly the same reason. Just as the old etymologists had no test to distinguish a true derivation from a false one, except a likeness in sound and meaning in the words compared, so the modern morphologist is yet without any sure test of the relationships of animals, except certain likenesses or unlikeness of structure. How much weight is to be allowed a given similarity, and how far this is offset by a dissimilarity which accompanies it, we have, as yet, few means of determining, and have still to discover those laws of organic change which shall render the same service to morphology as Grimm's law has done to the study of the Aryan tongues."

Philology was raised to the dignity of a true science by the laborious tracing back of modern words, step by step, to their ancient origins, through all their intermediate gradations, and sound principles of etymology could not be established until this was done. Morphology must profit by this lesson and must imitate the method of the science of language. Not until many long phylogenetic series have been recovered, can the law of change be worked out. It is just here that paleontology is fitted to render invaluable services to the common cause.

As every one is aware, the principal methods of morphological inquiry are comparative anatomy, embryology and paleontology, each of which has its great advantages, but accompanied by its own peculiar drawbacks and limitations. Lack of time will prevent any discussion of Bateson's proposed new method for the study of variation. I have elsewhere examined that at some length.

The foundation and corner stone of the whole structure of morphology must ever be comparative anatomy, an accurate knowledge of which is indispensable to successful prosecution of the other departments of inquiry. This method has, in the hands of the masters, registered many great triumphs in the solution of difficult problems of homology and of the mutual relationships of animal groups. At the present time the tendency is to give more and more weight to its determinations. On the other hand, finality cannot be reached by this method. It suffers from the very significant drawback of possessing no sure criterion by which to distinguish between those similarities of structure which result from actual genetic relationship and those which are due to parallel or convergent development, and thus to determine the taxonomic value of a given likeness or unlikeness. It is an exceedingly common fallacy to assume that, because a number of allied groups display a certain structure, their common ancestor must also have possessed it. This may have been the case, but it is almost as likely not to have been, because the structure in question may have been many times independently acquired. While the comparative method frequently enables us to discriminate between the two classes of phenomena, it generally does not do so, and it never can give entire certainty upon this point.

On comparing the humerus of the horses with that of the camels, we find in each a characteristic difference from other artiodactyls and perissodactyls and agreement with each other—a feature which may be described in brief as the duplicity of the bicipital groove and presence of a bicipital tubercle. It is *à priori* probable that such an isolated resemblance between two widely separated groups is due to convergence, and yet the comparative method can give us no

assurance that this is not a primitive ungulate character retained in these two series and lost in the others. Having recovered the various extinct genera of both these phyla, we may trace out the gradual transformation of the humerus and definitely show that the resemblance has been independently acquired at a comparatively late period, and is not a case of a persistent primitive feature.

In short, the difficulty of reaching firmly fixed conclusions upon questions of homology and relationship by the exclusive use of comparative anatomy lies in the fact, that this method deals only with the modern assemblage of animals, a mere fragment of that which has existed in former times. It is like attempting to work out the etymology of a language which has no literature to register its changes.

The second method of morphological inquiry, embryology, has had a somewhat chequered career. Not many years ago it was universally regarded as the infallible test of morphological theory, and the principle that the ontogeny repeated the phylogenetic history in abbreviated form was accepted, almost without question, as a fundamental law. But this view has fallen somewhat into discredit. The admission which very early had to be made, that 'cenogenetic' features of development were imposed upon or substituted for those due to ancestral inheritance, opened the door to an unduly subjective way of dealing with embryological evidence and deprived the method of that authoritative character which had so generally been ascribed to it. Now the whole recapitulation theory is boldly called in question, and, in the admirable lecture delivered last year in this place, Prof. E. B. Wilson showed the untrustworthy nature of the embryological criterion of homology. The difficulty in this case lies in the absence of any 'canons of interpretation' (to use Bateson's phrase) by which the contradictory data of embryology may be harmonized into a consistent whole. To take a concrete illustration: The ontogenetic development of the horse's teeth would give us a very inadequate and indeed false conception of the actual steps of change, by which the modern type of dentition has been attained, nor would embryology show that the horse is descended from five-toed ancestors. Knowing, as we do from the fossils, the phyletic series, the embryological facts may be readily understood. It is an undue reliance upon such facts which has led to the concrescence theory of tooth development, now so rife in Germany and which seems so absurd when viewed in the light of paleontology.

I have no intention of belittling the splendid services which embryology has rendered to morphology, but merely to point out that this method alone cannot reach finality any better than comparative anatomy. It resembles dealing with a literature that has been vitiated by many forgeries, only the grossest and most palpable of which can be readily detected.

A third method of attacking morphological problems is that offered by paleontology. Let us begin our consideration of this method by frankly acknowledging its drawbacks and limitations. (1) In the first place there is the imperfection of the geological record. Paleontology does not profess and never can hope to reconstruct the whole history of life upon the earth, or even the greater part of that history; very many chapters are irretrievably lost, and others are so fragmentary that they teach us little or nothing. The great sedimentary deposits which contain nearly the whole recorded history of the globe were laid down under water, and for a land animal or plant to be entombed there is a lucky accident. If all we could learn of the terrestrial life of North America had to be deciphered from

the fragments enclosed in the oceanic deposits along its shores, how very imperfect would our knowledge be! Although the estuarine, swamp and lake formations, which occur on such a grand scale among the rocks of the earth's crust, have preserved whole chapters in the history of terrestrial life with wonderful fullness and accuracy, they are all too few and too widely separated to form any complete record. Even in a continuous series of marine deposits, representing vast periods of time, there are sure to be gaps of greater or less importance in the record. Changes in the depth of water and the character of the bottom will drive out one set of forms from that locality and bring in another, which has no genetic connection with the former, which may perhaps return with a renewal of the old conditions. Many groups of organisms are incapable of preservation in the fossil state, except under the rarest conditions—conditions which occur so seldom, and so widely separated in space and time, as to render hopeless any attempt to reconstruct a continuous story from them.

The very circumstances under which organisms are preserved in the rocks offer another obstacle to the determination of phyletic series. On examining large collections of fossils from several successive horizons, we find that the majority of the species and even of the genera are confined to one or two formations, and that each succeeding fauna is recruited partly by migrations from other regions and partly by the rapid expansion of comparatively few adaptive and plastic types, while most of the forms which were especially well fitted for the older conditions die out under the new. The collections are, of course, largely made up from the abundant and dominant species of each horizon, which frequently are not the ancestors of those which will be dominant in the succeeding one. The sudden appearance, as it so often seems to be, of a fully differentiated group is sometimes due to that cause, sometimes to a migration from some other region. Even in phyletic series which are well-nigh complete there is a tendency for each successive genus to undergo similar cycles of specific variation, and this adds to the confusion, the very completeness of the record increasing the difficulty of its interpretation.

(2) a second drawback to the paleontological method of inquiry lies in the incomplete preservation of those organisms which are fossilized. Of plants we find, for the most part, only scattered leaves, rarely the reproductive organs, stems or roots, and often the proper association of the various parts requires the strenuous labor of years. Of animals, except under exceedingly rare circumstances, only the hard parts, teeth, bones, shells and the like, are preserved, and in the case of vertebrates how seldom is even the skeleton completely recovered! As in plants, the association of the various parts of a single skeleton may require the long continued and laborious efforts of many workers. Extraordinary blunders have sometimes been committed in this work. In the remarkable genus *Chalicotherium* the skull was at first referred to one mammalian order and the feet to another, and Forsyth-Major's suggestion that they all belonged together was received with incredulity. Of the even more curious *Agriochœrus* the head was ascribed to one order, the fore-leg to a second and the hind-foot to a third.

The utterly false notion, which nothing seems able to eradicate, that the paleontologist can readily restore an extinct type from a single bone or tooth, ought to receive its quietus from such examples, though of course it will not. It is equivalent to saying that we have nothing to learn from the fossils, and that all possible types of structure are exemplified in the living world.

On account of this incompleteness of

preservation we cannot learn much that we wish to know of the structure of extinct organisms. The nervous, vascular, muscular and alimentary systems are entirely lost and can be inferred only from indirect and often insufficient evidence. Were the pearly nautilus extinct, our notions of the anatomy of the tetrabranchiate cephalopods would be very much astray, and in the cases of several groups of fossils we are quite unable to interpret the structure from what remains.

(3) A third difficulty in the way of a truly morphological paleontology consists in the uncertainties of geological correlation, by which the relative age of formations in widely separated areas and different continents is to be determined. It may and often does make a vital difference in the construction of a phylogeny, whether a given set of rocks in North America is older or younger than one in Europe, with which it is correlated. The principles according to which such correlation is to be made are still somewhat indeterminate, and not a few geologists maintain that the problem is an insoluble one. On the other hand, it is essential to the paleontologist that it should be solved, and already a very encouraging beginning has been made.

(4) In the fourth place the apparent order of succession of organisms in the stratified rocks must not be too implicitly and uncritically accepted. Animals and plants diffuse themselves as widely as possible until stopped by some impassable barrier. During the long ages of the world's history these migrations have ever been in progress, and they greatly confuse the record when we attempt to read it in terms of evolutionary descent. A species in a newer formation, which appears to be derived from one in an older horizon of the same region, may, as a matter of fact, have had an entirely different ancestry and have migrated half around the globe to the place where it occurs. To make these distinctions theoretically is easy; to apply them very difficult.

(5) Lastly should be mentioned a practical drawback to the paleontological method, namely, its costliness. The naturalist may find much to do in other departments at small expense, which will be a source of infinite pleasure to himself and of great value to science. Every field and wood, every pond and stream, and above all the sea, offer boundless stores of material. Even the side of paleontology which bears upon stratigraphy and historical geology may be taken up to great advantage by the private worker who happens to live in a favorable locality. With paleontology as a branch of morphology, however, the case is unhappily very different. Here great collections brought together without much regard to cost, skilled workers to prepare the specimens, and great buildings in which to house them are indispensable. Distant regions must be examined and the whole world ransacked for material. Many problems connected with the North American fauna must await their explanation until Asia can be thoroughly explored, while Africa and South America have already shown what a complete geological knowledge of those continents may be expected to teach. In this country the arid parts of the West have yielded a marvelous store of wonderfully preserved fossils, but great sums have been expended in gathering them—an opportunity which falls to the lot of but few. It is to be hoped that the multiplication of museums may ere long put within the reach of all biological students something of these great stores of wealth.

It might well seem that all these limitations and drawbacks would necessarily disqualify paleontology as a morphological subject from being of the smallest real importance, but such a conclusion would be highly erroneous. Several of the limitations are but partial, not applying to par-

ticular cases, while others are difficulties that further investigation may hope to remove, not insurmountable obstacles. Every year new forms are discovered and better material of known forms. Though the White River Bad Lands have for more than half a century been classic collecting ground, hardly a season passes that several new genera are not registered from there, and, better still, types before known only from fragments are gradually made more and more complete. From the middle Eocene to the lower Miocene there is in the West an almost unbroken transition which is bringing forth a truly magnificent series of evolutionary stages.

While paleontology, as we have seen, does not profess to give an unbroken life history of the earth, yet it has certain preeminent advantages which neither comparative anatomy nor embryology possesses, and which fit it to form an invaluable supplement to those other methods of morphological investigation.

(1) In the first place, it gives us in many cases actual phyletic series in their true order of succession in time. In many groups of animals we have already recovered phyletic series so full, so complete, that no observer can hesitate to accept them as representing actually or very nearly the successive steps of evolutionary change in the order in which they occurred. Little confidence may, perhaps, be placed in these phyla by those who have not made a special study of them, and it may be imagined that fuller knowledge will require them to be completely changed. But when we find such a series as that of the horses, leading back by almost imperceptible gradations from the great monodactyl living forms to their little five-toed progenitors in the far distant Eocene times, doubt becomes well-nigh impossible. A limit of error is placed by the stratigraphical order, the geological and morphological successions coinciding beautifully. Whatever changes in the details of such a series may be needed, a radical reconstruction of it is not in the least likely to be called for. Few observers, if any, would now uphold the arrangement of the equine phylum proposed by Kowalevsky, namely, *Palæotherium*, *Anchitherium*, *Hipparion*, *Equus;* and yet it is surprising to see how the general character of this series, and the deductions as to the manner of evolution which may be drawn from it, agree with those made on the basis of the equine series as we now have it. Kowalevsky's mistake merely consisted in putting certain members of the side branches into the main line of descent, and that similar errors have been made in accepted phylogenies is not at all unlikely. The correction of such errors will, however, change the general result but little, and we may appeal with considerable confidence to the conclusions which legitimately follow from a study of these phylogenies.

Fortunately, the well-defined phyletic series which have already been made out occur in very widely separated animal groups—mammals, reptiles, cephalopods, brachiopods, echinoderms, etc.—so that the points in which they agree are apt to prove of general application and validity. The cephalopods are particularly valuable in this connection, because in them the embryonic and young stages of the shell are preserved in the adult, and thus conclusions have a distinct support from embryological considerations. To recur to the linguistic analogy, we have here at least fragments, and sometimes very extensive ones, of the various literatures which register the changes of language, and in the original documents which bear evidence of their dates and succession, and which, however incomplete, have not been falsified by forgeries and late interpolations. In this way we may establish unequivocally some, at least, of the animal pedigrees, which it is

one of the great objects of morphology to construct, and thus to correct the results obtained by the other methods of inquiry.

Paleontology further enables us accurately to discriminate between resemblances which are due to genetic affinity and those which result from parallelism or convergence.

To illustrate: On grounds of comparative anatomy, Flower classified the land Carnivora in three sections: the Cynoidea, or dogs; the Arctoidea, containing the bears, raccoons and mustelines; and the Aeluroidea, including the civets, hyenas and cats. This classification has found wide favor and very general acceptance, but paleontology proves it to be untenable. The extinct phyla show that the dogs and bears are very closely akin, as are the mustelines, civets and hyenas, while the cats occupy a very isolated position and are not nearly allied to any of the other families. The anatomical characters which suggested Flower's system are, in part, examples of convergence, and in part, due to the retention of primitive characters in some groups and their loss in others.

Again, reasoning from embryological data, Röse and others have propounded the theory that the complex, multicuspidate, mammalian tooth has been formed by the coalescence of many simple teeth. The phyletic series enable us to follow the evolution of these teeth step by step, and demonstrate the incorrectness of the 'concrescence theory.' In fact, the great lesson which the study of the phyla continually brings home to the observer is that trustworthy results are to be obtained only by the laborious and minute tracing of the changes through every step of the way. Fragmentary series are not to be depended upon, and the wider the gaps between their members the more uncertain is their connection.

(2) The reconstruction of pedigrees, the solving of homologies, the determination of relationships, and the establishing of classification upon a sound and natural basis, important as these are, are yet only a part of the great task which morphology has set before itself. We wish to penetrate more deeply into the mystery of nature and learn how and why these changes have occured; or, in other words, to discover the manner in which, and the efficient causes by which, development is effected. On these subjects there is, as yet, wide divergence of view among morphologists. The postulates and assumptions upon which morphological discussions are founded are, in great measure, incapable of proof, and appeal with very different degrees of force to different minds. Modes of development which appear axiomatic to one observer are by another regarded as absurd. All are agreed that there are limits to the possibilities of change; no one attempts to derive a butterfly from a beetle, or a horse from a cow; but just how and where these limits should be drawn it is at present impossible to say. It is this uncertainty which refers the question to the individual judgment and leaves the way open for such radical differences of opinion.

To the solution of these problems of evolutionary modes paleontology offers most valuable assistance, drawn from the study of actual phyla. It might seem that this was merely arguing in a circle, because the construction of phylogenetic series involves certain presuppositions as to what changes are and what are not possible, and we then proceed to prove the presuppositions by the phyla thus constructed. But the cautious, step-by-step method, guarded by the order of appearance in time, offers a way of escape, and enables us to construct phyla in harmonious structural and stratigraphical succession, which must very nearly represent the actual stages of change. Only a beginning has been made in this work, but the results drawn from an examination of

widely separated phyla, such as mammals, gasteropods and cephalopods, are so consistent and harmonious as to be full of promise for the future.

Limitations of time and space forbid an attempt to fully consider here all the deductions which have been suggested and rendered more or less probable by this method, but one or two principles which stand out with especial clearness may be mentioned.

(*a*) Evolution is ordinarily a continuous process of change by means of small gradations. The continuous character of a phylum is apt to be proportional to the relative abundance of its representatives in the strata, which is equivalent to saying that well-known series are continuous, while apparently discontinuous series are imperfectly known. This does not imply that the rate of change was always uniform—it probably was not—or that a sudden alteration of conditions may not bring about discontinuity, or *per saltum* development. It means that the usual and normal mode of advance is by continuity of change.

(*b*) Development is, in most instances, direct and unswerving. The rise of new forms, and the decadence and degeneration of old ones, are not ordinarily by zigzag and meandering paths, but by relatively straight ones; and though, of course, a path once taken may be diverged from, yet in such a case it is not regained. This applies particularly to the organism as a whole; in minor details more latitude is permissible. The evidence is not yet sufficient to show just how widely applicable this principle is.

(*c*) Parallelism and convergence of development are much more general and important modes of evolution than is commonly supposed. By parallelism is meant the independent acquisition of similar structure in forms which are themselves nearly related, and by convergence such acquisition in forms which are not closely related, and thus in one or more respects come to be more nearly alike than were their ancestors. While some observers have tacitly or explicitly denied the reality of these processes, most authorities have been compelled to admit them. What paleontology has done, and is doing, is to show the universality of these modes of development, and to point them out in directions where they had not been suspected. To give a few examples: The crescentic, or selenodont, molar has been separately acquired by no less than three groups of artiodactyls, and probably others as well. The spout-shaped odontoid process of the axis has independently developed in the horses, the tapirs, and in three artiodactyl series. The true ruminants (Pecora) of the present day are, among other characteristics, distinguished from the remaining artiodactyls by the hollow tympanic bullæ, which in the pigs, tragulines and camels are filled with cancelli, or spongy bone. In Oligocene times only the camels had acquired the cancelli; the other groups, though already differentiated as such, still had hollow and inflated tympanics. Lists of such parallelisms in single characters might be multiplied almost indefinitely, but they also occur in whole groups of structures. The camels have in teeth, skull, vertebræ and limbs many points of resemblance to the true ruminants, which demonstrably are not due to inheritance from a common ancestor. The two great series of ungulates, the artiodactyls and perissodactyls, which are usually grouped together as the Ungulata *par excellence*, are examples of parallel development on a grand scale, their many resemblances being for the most part independently acquired. The flesh eaters known as Carnivora include at least two, and probably three lines, which have been separately given off from the primitive flesh eaters, or creodonts.

Such a mode of development greatly increases the difficulty of determining phy-

logenies, which would be very much easier could every notable resemblance at once be accepted as proof of relationship. It often renders impossible the proper classification of some isolated genus which seems to have several incompatible affinities. It emphasizes the necessity of founding schemes of classification upon the totality of structure, and of determining the nature of characteristics, whether they are primitive or acquired, divergent, parallel or convergent, before attempting to assign them their proper taxonomic value.

We may find a practical identity in teeth, skull or feet as the outcome of these processes, but as yet no case is known where all these structures have become alike through the operation of either parallel or convergent development. Among the invertebrates the case is different. Hyatt has shown that the degenerate, straight-shelled, ammonoid genus *Baculites* is a polyphyletic group, and derived from several distinct stocks, both European and American. Würtenberger points out that the so-called *Ammonites mutabilis* is not a true species, but a composite group, made up by the convergence of several distinct lines to a common term. This case is peculiarly significant, because it would hardly have been detected had not the embryonic and young stages of the shells been preserved.

It seems the most obvious of commonplaces to say that numerous and close resemblances of structure are *prima facie* evidences of relationship. Yet the statement is true, even though the resemblances have been independently acquired, because parallelism is a more frequently observed phenomenon than convergence, and because the more nearly related any two organisms are, the more likely are they to undergo similar modifications.

All this brings us back to the thesis so frequently insisted upon already, that the only safe and trustworthy method of constructing phylogenies is by tracing the development, step by step, through all its gradations; and until this is done the classification of any group can be but tentative and provisional, that is, if we intend classification to express relationship.

No department of biological science is at present the scene of such vigorous controversy as that which deals with the factors of evolution, the causes which determine the development of new forms, and the problems of heredity which are inseparably connected with them. Paleontological evidence will prove to be of much importance in this connection also, but it cannot well have more than a corroborative value. Though the examination of long and complete phyla brings to light much that is suggestive concerning the factors which have brought these changes to pass, and any rational theory must embrace and explain these facts, yet the deciding weight must probably come through the physiological and experimental method. Time fails to deal with such far-reaching questions here, and yet it may be well to call attention to the necessity of avoiding a dogmatic and intolerant attitude, and to deprecate any premature attempt to exclude this or that class of factors from consideration. In most of the recent writings upon the efficient causes of evolution you will find expressed or implied the feeling that these matters are not so simple and intelligible as we once supposed, and that we are yet only upon the threshold of their solution. The study of paleontology will not tend to dispel this feeling of mystery.

Another department of biological science in which paleontology has proved of great value, and will become more and more so in the future, is that which deals with the geographical distribution and migrations of organisms. Though not a branch of morphology, this subject has a very significant bearing upon that science, and cannot be

ignored in any comprehensive theory of evolution. This, again, is too large a field to enter upon at the close of a lecture. It must suffice, therefore, to hint at the many cases in the existing distribution of animals, which seem so puzzling and capricious, and which are so readily explained by a study of the past. That the nearest allies of the South American llamas should be the camels of the Old World seems unaccountable, until we learn that North America was the original home of the entire tribe. The occurrence of the tapirs in South America and in the Malay peninsula becomes intelligible enough, when we learn that this genus is of very high antiquity, and was formerly represented in every part of the northern hemisphere.

The more fully the past is recovered, the more completely the former land connections of the various continents are made out, the more comprehensible do the seeming anomalies of the present order of things become—a proposition which applies to more than problems of geographical distribution.

The foregoing consideration of paleontology as a branch of morphological science is necessarily brief and very inadequate, but it will suffice, I trust, to show that its claims upon the attention of morphologists should not be ignored, and that it is admirably fitted to throw light upon many obscure problems. In conclusion, let me point out that final and lasting results are not to be gained by an exclusive adherence to any method of morphological inquiry, but by a combination of all of them. Each is able to supplement the others, and it is folly to reject such aid. Already most encouraging results have followed from this combined method of work, and it is devoutly to be wished that its scope may be more and more extended. As an example may be cited the recent investigations upon the mammalian dentition. From paleontological phyla we have learned to distinguish the homologies of the cusps, and the way in which a complex tooth is gradually formed from a simple one. Embryology, on the other hand, has shown the relations of the successive dentitions to one another in a fashion that paleontology could by no possibility accomplish unaided. As another example may be mentioned Wincza's discovery of a bony clavicle in the embryo of the sheep, which was soon followed by the still more unexpected one of vestigial bony clavicles in certain extinct artiodactyls, confirming and explaining the first. Embryology has taught us that the large element in the carpus of the Carnivora known as the scapholunar was formed by the coalescence of three separate bones—the scaphoid, lunar and centrale. Later the fossils were unearthed, which showed that the embryonic and transitory condition of the modern forms was the permanent and adult structure of the primitive Eocene flesh-eaters.

The more the combined method is employed the more fruitful does it appear. Nor should the combination be restricted to the technically morphological subjects. Experimental embryology has already won some notable triumphs, and that is a physiological quite as much as a morphological province.

In the ever-increasing complexity of modern civilization a more and more important rôle is played by systematic cooperation, specialists combining for joint work which neither could accomplish alone. Is it Utopian to wish that some such organized scheme of attack upon biological problems shall be devised, when, instead of every man doing merely that which is right in his own eyes, we shall combine in a definite, orderly way to investigate a given topic in all its bearings? It may well be doubted whether any naturalist, however great his genius, will ever again be able

to take such an exhaustive survey of biological data as Darwin did in his time. The enormous mass of accumulated facts already far transcends the power of any one mind to grasp, and it would seem that organized cooperation is the only method of dealing with such vast accumulations. When that time arrives, the paleontologist will be able to render even more conspicuously valuable services that he has done in the past.

W. B. Scott.

Princeton University..

ON PHOLADIDEA PENITA AND ITS METHOD OF BORING.

The Piddock of the northwestern coast, Pholadidea penita, is found in its curved conical burrow in the rocks near the tide marks. These rocks, so far as the writer's observation goes, consist of soft limestone or sandstone of varying hardness, the animal choosing the softer portions for its home. How the Piddock accomplishes the task of burrowing into the even moderately hard sandstone is a question upon which little light is thrown by an examination of the mature, or as I shall call it, the resting form, which is characterized by the complete absence of its foot muscles and an almost complete fusion of the mantle lobes along their ventral margin, leaving an opening hardly 2 mm. long. The inference is that Pholadidea penita is a degenerate form, as is the oyster. Further facts, however, will show that this degeneracy does not occur till late in life, when its burrow, the home of its old age, is completed.

The shell of the animal during its period of diligence, like that of other Piddocks, gapes widely in front. Through the upper portion of this gape protrudes a thick fold of the mantle which overlaps the antero-dorsal margin of each valve and secretes a layer of calcareous matter on the outside of the shell. The gape is much wider below

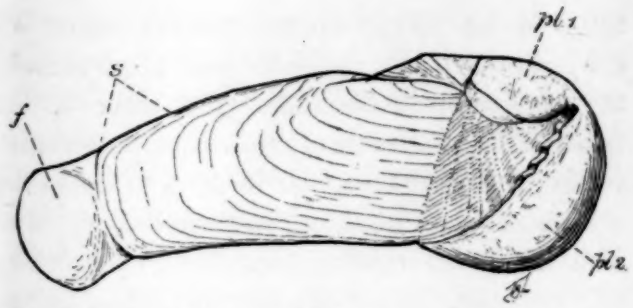

Fig. I. Left side of resting form, specimen 9 cm. long.

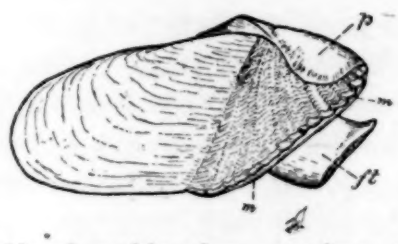

Fig. II. Left side of working form, specimen 6 cm. long.

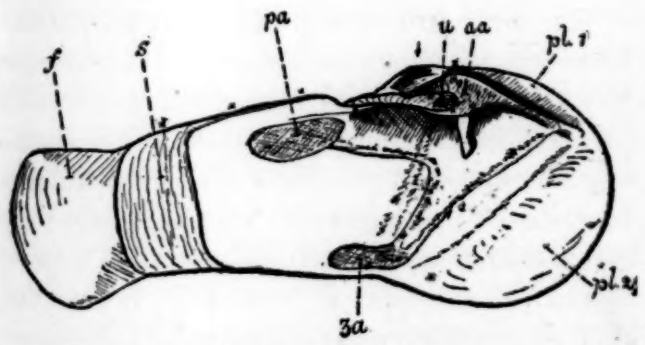

Fig. III. Inside of left valve showing hinge mechanism and muscle markings, specimen 9 cm. long; Siphon retracted in all. aa. Anterior adductor muscle mark; the arrow point indicates its posterior limit. 3a. Third adductor muscle mark at angle of pallial sinus. f. Cuticular flap. ft. Foot. m. Thick antero-ventral edge of mantle surrounding foot. p. Pad formed by antero-dorsal mantle folds. pa. Posterior adductor muscle mark. pl. 1. Plate secreted by antero-dorsal mantle fold, of that side. pl. 2. Plate secreted by m. in Fig. II. S. Additional extent of shell added at the same time with cuticular flap. u. Umbo. The leaders end in patch of abrasion, the point where the valves articulate. The small crosses indicate attachment of hinge cuticle.

and through it protrudes a strong cylindrical muscular foot, the muscles of which are attached at a point of vantage supplied by a curved process on the inside of each valve. The mechanical result of this ar-

rangement is that the foot moves about a point near the common axis of the animal and its burrow and not at one side, thus enabling the foot to work with equal advantage in all directions.

The mantle lobes are fused, except in the antero-ventral region (and, of course, at the siphonal openings), where an opening is found sufficiently large for the protrusion of the foot. The edge of the mantle opening seems to be provided with circular muscle fibres, by means of which the opening is kept just large enough for the foot. Specimens of this form when removed from the burrow will be found to have the foot armed with grit, and a glance at its size and musculature is enough to convince one that it is functional.

These characters remain unchanged until the work of drilling the burrow is completed. The depth and size of the hole will be determined by the number and frequency of the neighboring burrows or the hardness of the rock. Assuming that the work is finished and the author is ready to rest from his labors, let us see what changes take place. The foot, being thereafter of no use, begins to atrophy, till at last the muscular tissue is entirely lost, the whole bulk being taken up by the genitalia and digestive tract. As the foot disappears, the opening through which up to this time it has protruded grows smaller by further fusion of the mantle lobes, till there is left at the extreme anterior end a small opening about one and a half mm. in diameter. This opening is supplied with a sphincter muscle and two valves on the inside, so placed that egress of water at this point may be prevented. The opening seems to be used in drawing in water and débris chancing to be in the burrow.

As this fusion takes place the gape of the shell becomes closed by plates secreted by the antero-dorsal mantle folds above and by the thick mantle now closing in front of the foot below. This results in the complete armature of the anterior end of the animal. At the posterior end an extra length of shell and two cuticular flaps, leathery continuations of the shell, are produced. The shape and size of these is such that the burrow is completely closed at this point by them as by valves. After these changes have taken place there is no more boring done, and we have now the fully matured but degenerate animal. It is interesting to note that not infrequently other clams Saxidomus are caught when very small in the burrow of the Piddock. Such forms have, it is well known, a very strong and muscular foot, which, however, becomes functionless in imprisonment and dwindles away until it is almost, if not entirely, lost. The shell becomes elongate or otherwise changed from the normal shape by pressure of the walls which imprison it. Mussels, too, attach themselves by their byssus to the wall of the burrow near its mouth, where it is narrow, and become much elongated.

The absence of an elastic hinge ligament is a striking character, not only of this form, but of Piddocks in general, and of another allied form, Teredo. The valves are held in position each relatively to the other by the common cuticular investment, which is, however, rather thicker and stronger along the dorsal line. The point at which the valves actually come in contact is morphologically the outside surface of the umbo, thus forming a double ball joint about which the dorsal cuticle is so disposed as to give rise to an incomplete capsular ligament. In place of the hinge ligament we find that the anterior adductor muscle, instead of remaining inside the shell, extends backwards and dorsal to the umbones, so that contraction of this muscle does not result in closing the valves, as it, aided by the posterior adductor, does in other dimyarians, but in separating them ven-

trally and approximating them dorso-anteriorly. Compensation takes place, however, by the development of a third adductor muscle, which occurs at the lower angle of the pallial sinus. This adductor muscle is in fact composed of pallial muscles diverted to this use. Such a muscle occurs in Zirphæa and Teredo and another Piddock which I have examined, said to have been brought in ballast from Panama.

By means of muscles arranged with respect to the point of contact, as these are, the valves of the shell can be moved mutually in any plane excepting a dorso-ventral one. The antero-ventral margin of the shell of the working form is armed with teeth, which are constantly renewed by shell accretion, forming a good rasp. Certain scratches in the wall of the burrow show that this rasp has been used in enlarging the hole, the anterior mantle pad and foot being used as fulcra. There are, however, other scratches at the apex of the burrow which indicate that the foot armed with sand serves also as a drill, but all attempts to watch the operation have so far been futile.

Specimens of this form have been found by the writer showing all degrees of degeneracy.

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Pacific University,
Forest Grove, Oregon.

SIR JOSEPH PRESTWICH.

The Nestor of English geologists—Sir Joseph Prestwich—late professor of geology at Oxford, died on the 23d of June, last, at the ripe age of 84 years. The life of Prof. Prestwich covers the most eventful period in the past of geology. The problem whose solution has established the principles of the new science all arose during his lifetime, and of these all he could say with truth

"quaeque ipse vidi
Et quorum pars magna fui."

Born near London on March 12, 1812, he received his early education partly in England and partly in France, becoming later a student of University College, where his attention was chiefly turned to chemistry and natural philosophy, geological study not being then a recognized part of any course. While there he founded among his fellow students the Zetetical Society, composed of about 14 young men who arranged to lecture to one another for the purpose of mutual improvement.

Necessity, rather than inclination, turned his course into business, in which he was closely occupied for nearly 40 years, but during this long time his thought and his holidays were employed in his favorite topic, geology. It was his enthusiasm and stern earnestness that enabled him to accomplish so much in hours that most men would have devoted to mere amusement. The necessary books and travel were obtained by the strictest self-denial in personal expense, sometimes, perhaps, to an excessive degree, but the results became manifest in a series of investigations that rapidly brought him to the front, and resulted in his appointment to the chair at Oxford in 1874.

To enumerate the successive publications that came from his pen would scarcely befit this notice. A glance at the many problems that engaged his attention and which were in part or altogether solved by his efforts will prove more instructive and interesting. One of his earliest papers appeared in the transactions of the Geological Society of London in 1836, and contains an investigation of the Coalbrookdale coal field, but his attention was soon directed to the English and French Tertiary strata and their correlation, and from these he passed to the younger or quaternary deposit on which most of his later work was done.

In several years reports had been current of the occurrence of human relics in the form of flint implements in gravels of very

early date in France, but geologists on both sides of the channel received them with incredulity.

In vain did the discoverer, M. Boercher de Perthes lay the evidence before them. So firmly were they fixed in their traditional belief in the late date of the appearance of man that all his efforts failed to move them until Dr. Falconer visited the region, saw and was convinced. At his suggestion, Prestwich, Godwin, Austen and others went to Amiens, and the former in his paper before the Royal Society gained over his English brethren to the new faith which he had himself adopted on seeing the evidence presented in the valley of the Somme.

He even extended the limit of time which the French geologist had demanded by proving that the gravels were of at least two ages, and that the high level or older beds had been deposited before the valley itself had been excavated by the river.

In the same time was the report on the Brixham Cave in 1872, where new evidence of the vast antiquity of the human race was adduced and previous conclusions were more than supported. Those who can look back to the time can well recall the conditions and realize the boldness of the few who dared to stand for the new truth and face the storm of 'odium theologicum,' which set in at once and beat on their reputation. Years passed by before it began to blow over, and only disappointment, loss and mental suffering were the reward of many who read and believed and acknowledged their faith. It is hard now to understand the effort it cost twenty-five or thirty years ago.

Prof. Prestwich has taken an active part in the efforts to find coal in the southeast of England; in the discussion relative to the channel tunnel, in the investigation of deep sea temperatures and in the water supply of London, "nihil tetigit quod non ornavit."

His large work on geology, in two volumes, appeared in 1886 and 1888 with a geological map of Europe, and contains the matured results of his life's work. His energy continued almost to the last; papers on quaternary geology and the antiquity of man have been read or written as late as the year 1893.

Honors flowed in on the veteran geologist from all sides. He received the Wollaston medal in 1849, a royal medal from the Royal Society in 1865; he was President of the Geological Society of London from 1870 to 1872, Vice-President of the Royal Society in 1870 and 1871. He received the Telford medal from the Institute of Civil Engineers in 1874, was President at the reunion of the Geological Society of France, in 1880, and was elected a corresponding member of the 'Institute' in 1885. A short time only before his death he received from Her Majesty the honor of knighthood.

His later years have been spent at Darent Hulme, near Sevenoaks, Kent, a home after his own taste, as those who have had the pleasure of visiting him well know. Geology is worked into every feature and adorns every corner and panel. It stands in the beautiful chalk downs, overlooking the valley of the Weald, where he delighted to ramble and where his life was shared by Mrs. Prestwich, niece of Hugh Falconer, herself attached to the pursuits of her husband, whose latterly feeble health she guarded with loving care.

E. W. C.

CURRENT NOTES ON ANTHROPOLOGY.

RESEARCHES IN MEXICO.

THE rich soil of Mexico and Central America is never scratched but it yields a harvest. How much there is in that land of promise for the ethnographer and antiquary is well illustrated in the brief description of his journey from Mexico City to Guatemala, contributed by Prof. Starr to the Chicago *University Record*, for May 22,

1896. He did not find the 'pygmies' of which there was some talk at the American Association last summer; but the presence of cretins in the barrancas near Guadalajara was established. In Chiapas, many cases of *pinto* was observed and also of goitre. No reference is made to the remarkable antiquities of this state, but doubtless they were not overlooked. The pottery, lacquer work and native costumes are mentioned. A number of notes were made for future studies.

Prof. Starr has also translated and published a pamphlet on Aztec place-names from the works of Father de la Rosa and Dr. Peñafiel. It is to be regretted that this list was not revised before publication by some competent student of the tongue. Several of the explanations are certainly erroneous, and others doubtful. The Nahuatl is not a difficult language either in its phonetics or its composition, and it now has excellent dictionaries and grammars, of easy access.

A NEW ANTHROPOLOGICAL JOURNAL.

THE science of anthropology is developing so rapidly, the contributions to it are so numerous and in so many languages and publications, that Dr. G. Buschan of Stettin, very justly thought the time has come when a journal should be started intended to take in the whole field, and give a quarterly summary of the progress of the science the world over. This he has carried out in the *Centralblatt für Anthropologie, Ethnologie und Urgeschichte*, issued at Breslau (J. U. Kern's Verlag. Price 12 marks, 80 Pf., for this country).

It contains one or more original articles, one, for instance, by Dr. Orsi on the ancient necropolis of Novilara in Sicily, and one by Dr. Sergi on the distribution of the Mediterranean race. Most of the pages are, however, occupied with brief notices of the leading articles on the science in various journals, transactions and proceedings, or separately published, including books. They are intended to be descriptive rather than critical, and to serve as a running index of the literature of the science.

There is need of just such a publication, and every student of the science of man will be sure to find references to works and articles for which he will be grateful. It should acquire a good subscription list in the United States.

D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

SCIENTIFIC NOTES AND NEWS.

ADAPTATIONS IN CAVE-DWELLING ANIMALS.

THE influence of environment upon organisms is nowhere more striking than in the case of animals which find themselves accidentally lost in caves and which succeed in accustoming themselves to the situation in spite of its difficulties. M. Armand Viré gives some notes on his observations, in the *Comptes Rendus*. The principle difference in the situation consists in the absence of light and in the rarity of animal prey. The eye always becomes atrophied to a degree which varies with the species and also with the individual; there is sometimes a difference between the two eyes of a single individual. The eyes are to a certain extent replaced by other organs of sense; the antennæ of the Campodes become, in some individuals, twice as long as usual, and sometimes longer than the entire body. The tactile hairs with which the body is covered obtain an exaggerated development, and in the crustaceans sometimes even invade the ocular globe. Hearing does not seem to be accentuated, but the sense of smell is very acute, and a bit of tainted flesh becomes invaded in a very few minutes with a large colony of animals. The organs of digestion become very considerably modified in those species which are naturally carnivorous, and in two Staphylins the mandibles were found to be completely atrophied. Every animal is more or less completely depigmented; but those which had no trace of color remaining began to have numerous little black spots disseminated over the whole body after they had been kept for a

month in the light, and these spots were particularly abundant in those parts (antennæ and claws) which had been accidentally lost and were in course of restoration. C. L. F.

COLOR PHOTOGRAPHY.

M. GEORGES ADOLPHE RICHARD states in the *Comptes Rendus* that he has solved the problem (which has hitherto seemed insoluble) of reproducing and making permanent three separate proofs of the picture in the Becquerel process of color photography, and of superimposing them upon a single plate. His process consists in substituting for the reduced silver, which is deposited in the collodion at varying depth, corresponding to the crests of the standing waves produced by light of three fundamental colors, a coloring matter of the corresponding tone. There are two ways of accomplishing this: (1) the reduced silver is transformed into a salt which is capable of fixing or of precipitating the coloring matter in question, or (2) it is transformed into a salt which reacts upon the carbon derivatives and forms an artificial coloring matter in the place and of the thickness required. Three plates are formed for the three fundamental colors, the middle one on a gelatine film and the other two on glass. The superposition of these three layers in the exact place required offers no difficulty, and the colors are of absolute stability. The combined plate can, of course, be looked at at any angle, unlike the plate produced by the Becquerel process in its original form. At the same time comes the information that a Chicago photographer has perfected the Joly process; it would seem that the moment is not far distant when photographs which reproduce the natural colors of objects will be easily within reach. C. L. F.

THE EYESIGHT OF ENGLISH SCHOOL CHILDREN.

A REPORT has been presented to the British Education Department by Mr. Brudnell Carter on the vision of 8,125 children attending twenty-five elementary schools in London. The refraction of the eyes had in many instances to be determined from a simple ophthalmoscopic inspection owing to the objections raised by parents to the use of mydriatics, and interruptions occurred from holidays, non-attendance and other causes. 3,181 children, or 39.15 per cent., were found to have normal vision in both eyes; 1,016, or 12.5 per cent., had normal vision in the right eye and subnormal in the left; 700, or 8.6 per cent., had normal vision in the left eye and subnormal in the right; and 3,228, or 39.7 per cent., had subnormal vision in both eyes. Comparing the sexes, the total was made up of 3,928 boys and 4,197 girls; of these 43.7 per cent. of the boys had normal vision in both eyes, and 33.4 per cent. of the girls.

Mr. Carter is of the opinion that the eyes of London school children generally are not in any way injuriously affected by the conditions of elementary school life. Myopia is not of frequent occurrence, and Mr. Carter has failed to find any evidence of its progressive increase from younger children to the elder ones, or any correspondence between the degree and the prevalence of the defect and the quality of the lighting in the schools where it was found. He holds that the prevalence of subnormal vision is due to the fact that children so rarely look at distant objects.

THE OBSERVATORY OF YALE UNIVERSITY.

THE report of Dr. W. L. Elkin, who since it was written has been made director of the Observatory, to the managers for the year 1895–6, is as follows:

"The series of measures for the purpose of detecting possible large parallaxes of stars with large proper motion has been carried on during the past year by Dr. Chase and myself. A few stars have been added to the list to fill up the gaps which presented themselves in the course of observing. As at present planned, the work will be completed probably in the course of 1807, as far as the observations are concerned.

"The series on the parallaxes of the first magnitude stars is, as stated in my last report, practically brought to a close, and only a few points of discussion remain to be revised.

"A considerable portion of my time has been devoted to a final revision of the discussion of the work on Iris as it passed through the press. This has now been accomplished, and the work will shortly appear as Part IV. of

the work issued by Dr. Gill on the determination of the Solar Parallax by Heliometer measures of Asteroids.

"Dr. Chase has passed through the press his work on the relative places of the principal stars in the cluster in Comu Berenices, and it is ready for issue as Part V. of our Transactions.

"I regret to say that we were not successful in the past season in securing photographic records of meteor trails. The apparatus was put in use during several nights of the August showers, but no meteors appeared of sufficient brilliancy to impress themselves on the plates, which had necessarily become somewhat fogged by the strong moonlight. We were equally unfortunate in our attempts on the Leonids and Geminids in November and December, respectively. During this year we have had only two lenses in use, as no further ones of sufficient size and quality were to be found in the market. It seems wise, however, in view of the favorable chances for the Perseids this year and the approaching maximum of the Leonids, to make an especial effort to secure a complete battery for our mounting, as originally planned."

GENERAL.

THE National Forestry Commission, which, as has already been stated in this JOURNAL, is composed of Prof. Charles S. Sargent, chairman, Prof. Arnold Hague, Prof. William H. Brewer, General Henry L. Abbott, Gifford Pinchot and E. H. Shuster, has now inspected the forestry of North and South Dakota, Montana, Idaho and eastern Washington. About two weeks will now be spent in traversing western Washington forests and exploring the Olympic Mountains. The Commission will then proceed to California, thence to Arizona and Nevada, concluding its labors in Colorado in September.

THE German Geological Society held its 42d general meeting in Stuttgart, from the 9th to the 12th of August. In addition to the scientific sessions a number of excursions had been arranged. The German Anthropological Society held its 27th general meeting at Spires, from the 3d to the 6th of August, under the presidency of Prof. Virchow.

THERE has been erected this year at the Marine Biological Laboratory, Wood's Holl, a new building containing a lecture hall and a number of rooms for investigators. Like the other buildings, it is of wood, and finished in the simplest possible manner. The total cost, which has been defrayed by the Marine Association, was $2,900, exclusive of $500 for furniture. There are this year seventy-two investigators engaged in original research at the laboratory.

WE learn from *Nature* that by means of a rearrangement of existing scholarships at the Charing Cross Hospital Medical School, and by the establishment of a special fund, memorials have been founded to Dr. Livingstone and Prof. Huxley, both old students of the school. The memorial to Livingstone takes the form of an entrance scholarship of 100 guineas per annum, and that to Huxley of (1) an entrance scholarship of £55, open to the sons of medical men; (2) a second year's prize in anatomy and physiology, and (3) a lectureship dealing with recent advances in science and their bearing on medicine and surgery. The first of these Huxley lectures will be delivered in the anatomical theatre of the Medical School on Monday, October 5th, by Dr. Michael Foster.

THE death is reported by cablegram of Sir William Grove at the age of 85. He studied for the bar, and during the latter part of his life was Judge of the High Court of Justice. From 1840 to 1847, however, he was professor of experimental philosophy at the London Institution and made important contributions to physical science especially in the departments of electricity and optics, including the voltaic battery which bears his name. He was President of the British Association in 1856, and was one of the most influential members of the Royal Society.

DR. J. M. TONER, of Washington, died on July 30th at the age of 71. He had made many contributions to various departments of medical science. In 1871 he founded the Toner Lectures, now endowed with $5,000, the income of which is spent annually on two lectures containing some important contribution to medical science. In 1882 he gave his library, consisting of 28,000 books and 18,000 pamphlets,

to the general government, and this library is now a portion of the Congressional Library.

DR. T. M. DROWN has resigned from the committee of the American Chemical Society which is undertaking to unify the methods of color comparison and report on a standard for measurement of color in potable waters, and Mr. Allen Hazen, of Boston, has been appointed in his place.

THE International Electrical Congress met at Geneva under the presidency of M. Lurrettini from August 4th to 9th. Among the subjects proposed for discussion were magnetic units, photometric units, transmission of power to great distances, and the protection of high-pressure overhead conductors against atmospheric discharges.

A REPORT has been circulated in the daily papers during the past week stating that the steamer Hope was detained by an ice floe off the Greenland coast. This is now denied, though it is said that under the conditions of the present season it is not unlikely that the Hope will have any trouble with ice.

ACCORDING to the N. Y. *Evening Post*, a despatch from Tromsöe, Norway, says that the expedition organized in England by Sir W. Martin Conway for the exploration of the interior of Spitzbergen crossed the island from west to east, and back from east to west, in the middle of July. The crossing was extremely difficult, owing to the prevalence of storms, fogs and floods. This is the first crossing of Spitzbergen on record.

THE scientific societies of Mexico will hold a second national congress in the city of Mexico, beginning July 4, 1897.

IN order to give a wider circulation to the *Review of American Chemical Research*, edited by Arthur A. Noyes, which during the preceding year has been published in the *Technology Quarterly*, arrangements have been made to issue the *Review* also in the form of separate reprints from that journal. The reprints will, like the journal, be issued quarterly, and will be paged separately and provided at the close of the year with title page and index, thus making the *Review* a volume complete in itself. The purpose of the *Review* is to present in concise form, in a single publication, a complete summary of the results of current American chemical research.

THE first number of an 'Annuaire géologique et minéralogique de la Russie,' edited by N. Krichtafovitch, has been published by Weg in Warsaw. The contents will be written in Russian, French and German.

THE Marquis of Tweeddale, chairman of the Anglo-American and Eastern Telegraph Companies, has addressed the following to the American press: "A financial committee is about to be formed to inaugurate an international memorial to commemorate the inception and extension of submarine telegraphy connected with the names of Cyrus W. Field, Sir James Anderson and Sir John Pender. In view of its great international importance, the American press may think the desirability of establishing such a memorial a subject suitable to be dealt with in its editorial columns."

PROF. HOLDEN, of Lick Observatory, has received a letter from Miss Caroline W. Bruce, of New York, enclosing a check for $1,000 to be expended in purchasing needed apparatus for use at the observatory. This gift, together with that of W. W. Low, of New York, lately received, makes it possible to carry on important work, which would otherwise have to be laid aside.

MME. BAZANOVA, of Moscow, has given about $275,000 to the University of Moscow to found a clinic with twenty-five free beds for diseases of the ear, throat and nose.

THE Institution of Engineers of Japan now contains, according to the *Indian Engineer*, a total of 1,564 members. Of these 399 are full members, 1,121 associates, 11 honorary members, and 33 corresponding members. They include representatives of the different departments of engineering, and, as a rule, they have been well trained not only in the theory, but also in the practice of their work, and the majority of them have shown that they are thoroughly trustworthy. These facts easily explain why so few foreign engineers are employed in Japan.

IT appears from advices received in Washington that cholera in Egypt is now beyond the

control of the authorities. The report dated July 11th says that during the week before last fresh outbreaks occurred in sixty-nine different places, and last week in eighty-seven. During the seven days up to the first instant, 1,200 deaths were reported, and in the following six days 1,700 deaths. So far 8,069 deaths have occurred from the present outbreak, and it is feared that these figures will be largely increased before the disease runs its course.

Mrs. Todd is contributing to the N. Y. *Evening Post* and *The Nation* a series of letters describing the eclipse expedition to Japan under the direction of Prof. Todd. She states that the imperial government has given free transportation for the party and instruments on all the railways and steamboats. It appears that in addition to the parties from England, France and America, the eclipse will be observed from Esashi by Prof. Terao, of the Tokyo observatory.

Mr. Ritchie, the President of the Board of Trade, has stated in the British House of Commons that he will introduce a bill dealing with the metric system during the present session. There will be no time to proceed with it, but its introduction will give an opportunity for consideration and discussion during the recess.

Prof. J. Milne writes to the London *Times*, calling attention to the fact that seismographs in Italy and the Isle of Wight showed the commencement of a disturbance at 8 p. m. on June 15th (the day of the earthquake and tidal wave in Japan), which reached a *maximum* the following morning. Prof. Milne considers that this illustration of the reliability of instrument records is an indication of the value of the earth messages which would be obtained at a geodynamic observatory, which, it is hoped, may sometime or other be established in Great Britain.

The third International Congress of Psychology met in Munich from the 3d to the 7th of August. Of the 174 papers, the following were presented before the general sessions in addition to an address of welcome by the president: 'Pain,' by Charles Richet; 'Criminal Responsibility,' by Franz von Liszt; 'On the Localization of the Emotions,' by Guiseppi Sergi; 'On the Association Centers of the Brain, with Anatomical Demonstrations,' by Paul Flechsig; 'The Theory of Sensation,' by Franz Brentano; 'The Psychology of Genius,' by Frederic W. H. Myers; 'A Genetic Study of Primitive Emotion,' by G. Stanley Hall; 'A New Method of Testing Mental Ability and its Application to School Children,' by Herman Ebbinghaus; 'Individual Psychology,' by Alfred Binet; 'On Memory for Sensations,' by W. von Tschisch, 'The Conception of the Unconscious in Psychology,' by Th. Lipps.

The Report of the Parliamentary Committee appointed to consider matters of pressing need to Ireland has been recently issued. The principal recommendation contained in the report is for the creation of a department of agriculture and industries, to consist of a minister and a council representing these respective interests.

The Prince of Wales has presented to the Natural History Branch of the British Museum the remains of the large male Indian elephant which was brought home by him on his return from India in 1876, and placed in the gardens of the Zoological Society, Regent's park. 'Jung Perchad' was one of the finest and largest of Indian elephants ever brought to England, and now forms the central and most conspicuous object in the great entrance hall of the Natural History Museum at South Kensington, where it was placed recently.

Natural Science states that Mr. E. A. Fitzgerald leaves England in September for Chili, to explore the summit of Aconcagua, 23,200 feet. It is stated that the sum of nearly £4,000 has been spent in preparation for the scientific work of the expedition.

The University of Edinburgh has conferred the degree of Doctor of Laws upon Francis A. Walker, President of the Massachusetts Institute of Technology.

Prof. Chas. D. Walcott, director of the U. S. Geological Survey, has been detained in Washington by office duties. He recently completed and submitted to the Secretary of the Interior the Annual Report of the Survey for the fiscal year 1895–96, which he anticipates will be published with less delay than has marked the issue of the previous volumes of the

series. He left the city August 3d and proposed spending August in the field, giving a week in the early part of the month to investigations in the slate-belt of western Vermont and eastern New York with Prof. J. F. Kemp and T. Nelson Dale, and, later, going west and working in the mountain regions of Nevada and central Colorado.

PROF. CHARLES S. PROSSER is in charge of the party studying the Permian and Lower Cretaceous formations of central and southern Kansas for the Kansas Geological Survey.

CHARLES GRIFFIN & Co. have published the thirteenth annual issue of the *Year-Book* of the scientific and learned societies of Great Britain and Ireland. The work, which extends to 262 pages, gives the officers of the various societies and the papers read before them during 1895. The information is in most cases contributed by the societies and offers an accurate and comprehensive survey of the contemporary condition of science and the arts in the British Islands. The number of different societies is very great, and the amount of work accomplished is almost bewildering. A similar *Year-Book* for America would prove useful, but we fear its contents would be small in comparison.

MR. HENRY HARBEN recently established a lectureship, under the auspices of the British Institute of Public Health, of the annual value of fifty guineas, 'for the encouragement of original research in connection with public health,' the lecturer to deliver three lectures in the course of the year. Mr. Harben founded at the same time a gold medal of the value of fifty guineas, to be awarded annually for 'eminent services to public health.' The medal has been awarded to Sir John Simon, and Dr. Klein has been chosen for the first lecturer. Dr. Klein took as subjects for his lectures 'Recent Research in the Identification of the Typhoid Bacillus' and 'The Cholera Vibrio.'

WE take the following items from *Natural Science:* Léon Diguet, who has recently returned from a scientific exploration in Mexico, is being set out again by the French Minister of Public Instruction. He proposes to study the Indians of Guadalajara, Sinaloa and Sonora, as well as the Cahuila Indians of S. California. Dr. M. Raciborski, of Munich, has been sent to the Buitenzorg Botanical Gardens. Prof. V. F. Brotherus, of Helsingfors, has gone to Central Asia to work out the bryological mountain flora of Issikul. A party of four, under the direction of Mr. T. H. Mobley, will start from Lacomb, Alberta, to explore northern Canada from Edmonton to the Arctic Sea. The trip is to occupy two years. Mr. J. C. Willis, late Frank Smart Student of Caius College, Cambridge, has been appointed Director of the Royal Botanic Gardens of Ceylon.

THE first brochure of the third volume of the *Proceedings of the Rochester Academy of Science*, recently published, is a monograph of 150 pages, containing a study of the *Plants of Monroe County, N. Y., and Adjacent Territory*, by Florence Beckwith and Mary E. Macauley, assisted by Joseph B. Fuller. The list aims to include the names of flowering plants growing without cultivation in Monroe county and adjoining counties, the area in general being the lower drainage basin of the Genesee River, with that of Irondequoit Creek and smaller streams upon the lake border, and it is believed to be nearly complete for Monroe county. A map is appended designed to serve as a guide to the region. The total number of species native to the Monroe flora is 948 ; the introduced species number 250, making a total of 1198 species. There are 103 native and 13 introduced varieties, making in all 1304 species and varieties, of which 1208 are found in Monroe County. The monograph includes a full bibliography and an index to orders and genera.

THE London *Times* states that the additions to the museum of Royal College of Surgeons of England during the past collegiate year have been numerous and valuable. In the department of human and comparative anatomy the most noticeable addition is a magnificent specimen of the gigantic extinct bird, the Moa (Dinornis maximus), from the South Island, New Zealand. It was obtained through the kindness of Mr. Hutton, of Canterbury, New Zealand. This skeleton is especially interesting, as possessing both coraco-scapulars and both big toes. Neither of these are present in the specimen in the British Museum. Professor Charles Stewart,

F.R.S., presented four groups of Lepas fascicularis. These barnacles attach themselves to minute floating foreign bodies, whose buoyancy soon becomes insufficient of itself for their support. A secretion from the cement glands is, however, poured upon the surface of the foreign body in large quantities and covers it to a considerable depth with a natural float in the form of a spongy reticulum full of air bubbles. In one of the specimens part of the float has been removed to show the attenuated stalks of the barnacles attached to the foreign body. There is also a very good skeleton from a case of Osteitis Deforamans, showing in a marked degree the changes characteristic of that disease. Altogether some 360 specimens have been added to various departments of the museum.

At a meeting of the Geological Society of London, on June 24th, Sir William Dawson said that the whole of the facts were tending to the conclusion that instead of ascribing the phenomena of the glacial age to continental ice sheets, we should have to be content with local glaciers on the higher lands and cold ocean currents pervading the submerged lower levels. Evidently the phenomena could not be explained without giving attention to the evidence of continental submergence afforded by the clays containing marine remains and the ancient shore lines found at very high elevations. The action of shore and field ice during periods of gradual subsidence and elevation could alone account for the great beds of boulder clay holding marine shells and tests of modern foraminifera, and the term 'unstratified' till was not always appropriate, as where long continuous sections could be observed, successive beds were often marked by color lines, by rows of stones or by fossiliferous layers.

The London *Times* states that the naturalists of the English Marine Biological Association have recently been paying particular attention to the question of the collection of fishery statistics, and an important report on the subject has just been received by the Council of the Association. In this report an account is first given of the statistics at present collected and published by the Board of Trade relating to sea fisheries in England. It is pointed out that the methods at present adopted for collecting the statistics are not such as to give confidence in the accuracy of the returns, whilst their inadequacy in plan and extent cannot be questioned. The defects upon which emphasis is principally laid are the want of sufficient discrimination between the species of fish landed, the lack of all information as to the locality of capture of the fish, and the fact that no attempt is made to distinguish between the products of different methods of fishing. Various suggestions are made as to methods by which the statistics could be improved, and it is maintained that the only really satisfactory course would be to require the master of each fishing vessel to supply the Board of Trade with correct returns of the fish caught and of the locality of their capture. In the case of the larger vessels, at any rate, such records already exist and are supplied by the master to his owners. All that is required is that copies of these records should be furnished to the proper officers, so that the information may be utilized for the general benefit of the public and of the fishing industry. The report will be published in full in the forthcoming number of the journal of the Association.

The *Optician* states that a report which has just been issued by the Assistant Secretary of the Marine Department gives particulars of the working of the new tests for vision adopted by the mercantile marine during the 16 months ended December 31, 1895. A supplementary plate contains specimens of the colors of each series of wools used in the Holmgren test for color blindness. During this period the percentage of failures in color vision was slightly higher than under the old system, the percentage under the old system being .88, while under the new it amounts to 1.39. The total percentage of failures under the new system, including failures in form vision as well as those in color vision, was 2.8, while the total percentage of failures under the old system was .88. One commendable feature of the new system is the appeal to special examiners which is allowed when a candidate fails to pass in colors. Of the 101 candidates who failed in colors, 21 availed themselves of this appeal; 8 were passed and

13 rejected. For candidates who fail to pass the form vision test no appeal is provided, but they are allowed to be re-examined at intervals of three months. Twelve candidates out of the 115 who failed to pass the form vision test have been subsequently passed. The number of officers already in possession of certificates of competency who on coming up for examination failed to pass the tests was 53; 4 masters, 5 mates and 15 second mates failing in colors, and 1 master, 12 mates and 16 second mates in form vision. No case of failure to pass the test for color ignorance has been reported.

Natural Science states that two marsupials (*Dasyuroides byrnei*, n.g. et sp., and *Sminthopsis larapinta*, n. sp.) were discovered by the Horn expedition in central Australia, and are described by Prof. Baldwin Spencer in the *Proceedings of the Royal Society of Victoria*, vol. viii., pp. 5–13, as well as further described and figured in the account of the Horn expedition. *Dasyuroides* is a burrowing, insectivorous marsupial of nocturnal habits, which in the general form of the body closely resembles a large *Phascologale* or a small *Dasyurus*, while its dentition is also like that of those species of *Phascologale* which approach *Dasyurus*. The skull, on the other hand, agrees with that of *Sminthopsis* in the character of the nasal bones, while the hind foot in shape and in the absence of a hallux differs from that of both *Phascologale* and *Sminthopsis*. The specimens on which the description is based consist of six males and one female, and the dimensions of an adult male in alcohol are: Head and body, 182 mm.; tail, 130 mm.; ear, 18 mm.; hind foot, 38 mm. The new *Sminthopsis* is a small mouse-like form, separated from the two known species, *S. murina* and *S. crassicaudata*, by a long, very stout and highly incrassated tail, and by the greater relative length of the hind foot.

UNIVERSITY AND EDUCATIONAL NEWS.

PROF. C. S. BROWN, of the Rose Polytechnic Institute, Terre Haute, Ind., has been elected adjunct professor of mechanical engineering in Vanderbilt University in place of Prof. William T. Magruder, who goes to the Ohio State University.

MISS MARY F. WINSTON, of Chicago University, has received the degree of Ph. D. *magnum cum laude*, at Göttingen University. Miss Winston is a graduate of the University of Wisconsin and subsequently studied at the University of Chicago. She is said to be the second woman to receive the degree of Ph. D. from a German university.

MR. G. F. STOUT, Fellow of St. John's College, Cambridge, and editor of *Mind*, has been appointed to the Anderson lectureship on comparative psychology, recently founded at Aberdeen.

THE *Lancet* states that the Council of University College, Liverpool, have nominated Dr. H. E. Annett to a scholarship of the value of £150 a year, tenable for three years, awarded by the Commissioners of the 1851 Exhibition for further researches in scientific subjects and scientific study. Dr. Annett has given an undertaking to the Commissioners to proceed to one or more of the large Continental colleges where facilities exist for carrying on the study of pathology and bacteriology.

PROF. LIONEL S. BEALE has resigned the chair of medicine at King's College and the office of physician to King's College Hospital. Prof. F. Jeffrey Bell has also resigned the chair of comparative anatomy which he has filled for seventeen years.

A CHEMICAL dyeing school for instruction and research has been built at Crefeld under the auspices of the German government at a cost of about $100,000.

DISCUSSION AND CORRESPONDENCE.

THE NAMES EPIPHYSIS, CONARIUM AND CORPUS PINEALE: CORRECTION OF AN ERROR.

TO THE EDITOR OF SCIENCE: In your publication, July 17, p. 71, of the Report of the Committee on Neuronymy which was adopted by the American Neurological Association June 5, 1896, occurs an error which is unaccountable, but for which I must be held responsible. After the word *epiphysis* comes the date 1895, as if indicating the adoption of that word by the Committee of the Anatomische Gesellschaft in that year. On the contrary, they prefer *corpus pineale*.

The occurrence of this particular error exemplifies the 'irony of fate.' Among the forty terms on the list this is the only one to which my own conversion was recent. For years I used *conarium* without variation. The change was due to four considerations: 1. The arguments of Prof. H. F. Osborn and Dr. E. C. Spitzka. 2. The recognition of the desirability of verbal correlation with the ventral extension, hypophysis ('*corpus pituitarium*') and the other dorsal outgrowth, paraphysis. 3. The fuller appreciation of the force of Dr. W. H. Dall's declaration, "The human mind wearies of too many names and much more readily assimilates a new meaning for an old one."* 4. The abandonment, or rather relaxation, of one of the requirements of technical terms which was enunciated twenty-five years ago, viz., 'independence of context for signification.'† It is hardly conceivable that any misapprehension should arise from the employment of one and the same word, *epiphysis*, for a part of the brain and for the end of a long bone.

Permit me to express the hope that journals that republished your article may likewise print the corrective portion of this letter, and also to state that the next number of the *Journal of Comparative Neurology* will contain an extended commentary upon the report of the Neurological Association, together with correspondence on the general subject between Prof. W. His and myself. BURT G. WILDER.

SIASCONSET, MASS., August 3, 1896.

THE METRIC SYSTEM.

TO THE EDITOR OF SCIENCE: I was much interested in Mr. Stover's query, "Is not the country ripe enough to accept the metric system?" and wish to say that the practical difficulties are probably largely overestimated. Of all peoples those of the United States, are the most adaptive, and the change would involve those who are best able to assimilate the new method.

As Greeley proclaimed about 1871, "The way to resume is to resume," so the way to adopt is to adopt. If those from whom the initiative must come would initiate, there would not be much trouble. Let all architects and builders write their dimensions in metric measures, and they will soon find them executed without trouble.

This company manufactures pulleys, etc. A few years ago we established an agency in France and our orders came in metric measures. We simply sent to Chicago for a metric scale and then filled the order. It did not cause any noticeable trouble. It is just as easy for the saw-mill man to cut his lumber according to one measure as the other, and in a short time he would become equally familiar with both systems, and *then* the metric system would be established. The same results would follow through all the trades, but the workman will not use the improvement until he is obliged to.

R. D. D. SMITH.

DODGE MANUFACTURING CO.,
MISHAWAKA, IND.

*From a letter to me. Published as Aphorism xv. in the article 'Anatomical Terminology,' Reference Handbook of the Medical Sciences, VIII., 520, 1889.

†'Intermembral Homologies,' Boston Soc. Nat. Hist., Proceedings, XIV., 172, April 5, 1871.

SCIENTIFIC LITERATURE.

MATHEMATICAL PAPERS READ AT THE INTERNATIONAL MATHEMATICAL CONGRESS HELD IN CONNECTION WITH THE WORLD'S COLUMBIAN EXPOSITION, CHICAGO, 1893.

THE papers presented at the Chicago Mathematical Congress of 1893 have recently been issued in book form by Macmillan & Co., under the suggestive subtitle of Vol. I. of Papers Published by the American Mathematical Society. The papers are edited by the Committee of the Congress, Professors Moore, Bolza and Maschke, of the University of Chicago, and Prof. White, of Northwestern University. The committee were embarrased at the outset by the fact that no financial provision had been made for the publication, which was finally made possible by the generous subscription of a guarantee fund of one thousand dollars by the Mathematical Society, its members individually and other mathematicians. The handsome volume before us reflects great credit on all concerned in its production.

The Congress was decidedly cosmopolitan in the authorship of the papers presented and the subjects treated. Of the forty-five papers, fourteen were from America, two from Austria, four from France, twenty from Germany, three from Italy, one from Russia and one from Switzerland. Germany was officially represented at the Congress by an Imperial Commissioner, Prof. Felix Klein, of Göttingen, who brought nearly all the papers contributed by his countrymen. It is a singular circumstance that the British Empire did not furnish a single contribution nor a single representative. Roughly classified, seven of the papers deal with geometry, ten with theory of functions, eight with the theory of groups, seven with the theory of numbers, two each with differential equations, invariants and mechanics, and seven with miscellaneous subjects.

In his opening address before the combined Congresses on Mathematics and Astronomy, Prof. Klein drew attention to a matter of great interest to all scientists, viz., a present marked revulsion from the tendency of mathematics to run into isolated specialities, which has been so pronounced for a century. At present the movement is decidedly toward unification and breadth, not only in mathematics itself, but in its relation to other sciences. The general conceptions of 'function' and of 'group' are powerful coordinating elements. Two of the Chicago papers are especially mentioned by Klein as representing the new tendency. One of these, by Schönflies, deals with the connection between the theory of groups and crystallography. The other, by Burkhardt, discusses the relations between astronomical problems and the theory of linear differential equations. A third paper, by Fricke, on the automorphic functions and arithmetic (*i. e.*, theory of numbers), illustrates the work of Klein's own school in the unification of strictly mathematical branches.

Of the other papers on the theory of functions, one is by Bolza, on Weierstrass' system of hyperelliptic integrals; one by Hermite, on certain fundamental propositions in the theory of elliptic functions; one by Krause, on the transformation of the fifth degree of the hyperelliptic functions of the first order; two by Macfarlane, on the definition of the trigonometric functions, and on the principles of elliptic and hyperbolic analysis; one by Pincherle, in summary of certain results relative to the theory of recurrent systems of functions; two by Pringsheim, on the expansion of functions in series and convergency and divergency; and one by Stringham, on a formulary introductory to elliptic functions. Maschke, Moore, Meyer, de Perott, Taber and Cole have articles on special topics in the theory of groups. Halsted gives an account of some salient points in the history of non-Euclidean and hyper-geometries. It is, of course, impossible here to give any detailed account of the contents of these or the other valuable papers in the list. The moral of the present publication, as representing the International Congress, lies not so much in the specific contents of the book, as in the fact that America's workers in mathematics are constantly coming into closer affiliation with those of other lands and strengthening their scientific position by this connection. The other sciences have long had this advantage, but mathematics has received it only within a few years. Our position in this country has been so isolated, and our science so backward here in development, that it will probably be news to most of our colaborers in other fields that the development of mathematics in the present century has probably been as great in actual permanent substance as that of any other science now existing. And it is the function of such meetings as that at Chicago to stimulate the growth of the science and to secure it the recognition to which it is entitled.

F. N. COLE.

COLUMBIA UNIVERSITY.

RECENT TEXT-BOOKS OF GEOMETRY.

Elements of Geometry. By GEORGE C. EDWARDS, Associate Professor of Mathematics in the University of California. New York, The Macmillan Company. 1895. 8°. Pp. xvi+293.

Plane and Solid Geometry. Suggestive Method. By C. A. VAN VELZER, Professor of Mathematics in the University of Wisconsin, and GEO. C. SHUTTS, Professor of Mathematics in the State Normal School, Whitewater, Wis.

Madison, Wis., Tracy, Gibbs & Co. 1894. 8°. Pp. viii+395.

Plane and Solid Geometry. By Wooster Woodruff Beman, Professor of Mathematics in the University of Michigan, and David Eugene Smith, Professor of Mathematics in the Michigan State Normal School. Boston, Ginn & Co. 1895. 8°. Pp. ix+320.

These three text-books of geometry all show points of interest and excellence, and bear testimony scientifically and pedagogically to a spirit of progress. It is natural to turn at once to the first few pages of each book, and examine the manner in which the difficult problem of giving the beginner a good start is treated. It is not easy to communicate to the student the fundamental principles upon which the geometric structure is to be based. A rigorous scientific analysis or discussion of these principles is entirely beyond his comprehension. It is generally necessary for him to commit to memory the first dozen pages, to exercise his powers of reason by tracing the subsequent development, and, having become somewhat familiar with the methods of logical argument, to return to the beginning of the text-book for a more complete appreciation of the fundamental ideas.

In order that the student may have some acquaintance with geometric notions before taking up the study of demonstrative geometry, it is desirable that such study should be preceded by simple mechanical drawing and a course in inventional geometry so-called. But the training that he will gain only from the study of demonstrative geometry is necessary before he can appreciate to any extent the character and content of the definitions, axioms and postulates of geometry. It is, of course, very satisfactory to have the first few pages of the text-book constructed so that they meet all the needs of the mature student who turns back to them for a rigorous scientific discussion ; but it is of prime importance that these pages should convey to the beginner intelligibly and helpfully the information which is neccessary for his first steps in the demonstration of geometrical truth. That the definition of a straight line should be based upon the notion of direction, as it is done in the text-books of Wentworth and Wells, in Davies's Legendre, in Byerly's edition of Chauvenet and in other popular works, or that it should be based on the notion of distance, as is done in the original edition Chauvenet, are points which may seem appropriate for criticism to the mature student who seeks to subject every definition to a scientific analysis ; but the beginner will accept at once certain notions of direction and distance, of straight lines and curved lines, and it will be fatal to his progress to stop him at the threshold of the subject for a complete discussion of these ideas.

In the introductory portions of the three books before us intuitive methods are used most largely by Edwards; scientific accuracy of treatment is maintained most fully by Beman and Smith. For example, Edwards uses direction in defining a straight line, and assumes that a straight line is the shortest distance between two points. Van Velzer and Shutts avoid the use of direction as a fundamental notion, but adopt as an axiom that the straight line is the shortest distance between two points. Beman and Smith, however, wishing to make no unnecessary assumptions, demonstrate at length, like Euclid, that one side of a triangle is less than the sum of the two other sides. The last mentioned work will probably be most satisfactory to the advanced student, but it is quite likely that the beginner may prefer one of the others.

The Elements of Geometry by Edwards consists of fourteen chapters, of which the first eight relate to elementary plane geometry, the following five to solid geometry, and the last one to the conic sections. The propositions are not numbered in the traditional manner, but the work is divided into articles which are consecutively numbered.

In many of the propositions the demonstration is preceded by a discussion, or 'analysis,' in which are obtained the materials for the construction of the formal proof. In many others the demonstration is of an informal character, a mere outline being given, which, however, the student will have no difficulty in completing. Unusual and ingenious methods of proof are frequent. The surfaces of the cylinder and cone are measured by unwrapping them upon a plane. In applying the method of successive approximation to calculating the area of the

circle of unit radius, the formulæ are put in the very convenient form

$$\frac{1}{a_{2n}} = \sqrt{\frac{1}{a_n} \cdot \frac{1}{A_n}}, \quad \frac{1}{A_{2n}} = \frac{1}{2}\left(\frac{1}{A_n} + \frac{1}{a_{2n}}\right),$$

where small letters denote the areas of inscribed, large letters the areas of circumscribed regular polygons, the subscript in each case indicating the number of sides. Several of the proofs given deserve censure. For example, that in which the author claims to prove that the sum of the exterior angles of a polygon is four right angles is worthless, and that which establishes the area of a rectangle is very incomplete.

The Plane and Solid Geometry of Van Velzer and Shutts consists of eight chapters, five relating to plane geometry and three to geometry of three dimensions. The so-called suggestive method is employed. Each theorem is illustrated by a figure, and a series of suggestions follows, so arranged as to indicate the successive steps of the demonstration. Frequently a 'model' is given showing how the suggestions are to be combined so as to produce a complete formal proof. Numerous original exercises are scattered through the text, the whole number being almost four hundred. Each chapter closes with a syllabus of the preceding propositions so as to facilitate the student's reference to them.

Although the Plane and Solid Geometry of Beman and Smith is more extensive than either of the other works under consideration, its publishers by giving it a very compact form have been able to make it even less bulky than the others. It consists of eight books, of which five are devoted to plane geometry and three to solid geometry. An appendix to book III. discusses the various methods of attacking geometrical propositions, while an appendix to book V. treats of the special topics, maxima and minima, concurrence and collinearity. The work contains almost eight hundred original exercises, and at the end are appended a table of formulæ and numerical constants, a biographical table, a table of etymologies and an index. A slight but sufficient treatment is given of symmetry, the notion of positive and negative magnitudes, the principle of continuity, duality, the method of loci and the parallelism between certain propositions of geometry and algebra. The work thereby gains interest and modernness. Clearness and conciseness are given to the proofs by breaking them up into successive steps numbered, in order that they may be the better referred to, somewhat after the manner of the equations in many text-books of algebra. From a scientific point of view, this work is one of the best yet published.

THOMAS S. FISKE.
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American Fonostenografy.—A modern system of rapid shorthand * * * formulating and applying an entirely original principle of legibility and brevity—the fonostenografic root. By WILLIAM MCDEVITT, LL.M. Judd & Detweiler, Printers, Washington, D. C.

The author of this work has sought to raise shorthand to the rank of an art of expression coordinate with speech and writing, and he has wrought with masterly hand his materials into a definite system based on practical scientific principles. The requirements of a rapid and legible system of graphic expression are clearly set forth and the means for supplying them are provided; and the structural laws on which the system is based are fundamental principles in the genesis and development of human expression, which the author seems to have attentively studied. He grasps firmly a cardinal principle of linguistic growth, *i. e.*, that meaning and sense inhere in context and not in the isolated syllable or word, and teaches that he who sets himself the task of mastering the composition of phrases, clauses and sentences acquires thereby the key to successful fonostenografic practice. A fundamental distinction between the principles of contraction employed in this system of shorthand and the rules of abbreviation applied in older stenographies is that in the latter vowels are not specifically symbolized because they *are* vowels, consonants because they *are* consonants, and final initial syllables because they are such—for in McDevitt's system of vocalized fonostenografy, contraction is attained by the omission of factors or elements which are not 'strong and significant,' without regard to the adventitious